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FOREST INSECT INVESTIGATIONS

CORRECTION FACTORS FOR USE IN ESTIMATING TOTAL SEASONAL BARKBEETLE LOSSES IN CALIFORNIA

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CORRECTION FACTORS FOR USE IN ESTIMATING TOTAL SEASONAL BARKBEETLE LOSSES IN CALIFORNIA

Introduction

Forest insect surveys in California are usually carried on during the summer and early fall. A correction factor must be applied to these results to estimate the total seasonal loss, since only partial seasonal losses are in evidence at the time of the surveys. The use of the proper correction factor is important in planning costs and amount of work necessary in control projects.

Keen* has described a method for use in estimating total seasonal losses from partial seasonal losses obtained from the surveys. This method, applicable to southern Oregon and northern California ponderosa pine types, is based on the theory that losses will increase evenly from the first attack in the spring until the last attack in the fall. The correction factor to be applied on any date would fall on the straight line joining these two points.

Estimations based upon the above method have not checked with actual conditions found in the modoc, Lassen, and Plumas national forests in northern California. A study has been made, therefore, to determine a correction factor which will apply more directly to these areas and also to the westside Sierra region. The effect of certain variable factors found on these areas will be considered in arriving at the proper correction factor to be applied.

Methods

The curves forming the basis for correction factors to be used on the several areas in question are based upon annual insect surveys made on a large number of permanent sample plots. These surveys were made from early summer in some years to late fall in others; some years providing several cruises on the same plots.

A series of curves was constructed for each of the areas included in the study, plotting the percentage of total number of trees killed on any date. A curve was made for each plot, data permitting, and from these an average curve was drawn showing the percentage of total annual loss cruised at any date during any one season (Fig. 1, 4 and 5). The former, by their variation and grouping, showed, either directly or indirectly, the influence of certain environmental factors.

Keen, F.P. Estimating Pine Beetle Losses During Period of Attack Portland, Oregon, February 6, 1931.

Whenever possible, the above factors were examined for their modifying effect upon the average curves of the percent of the total seasonal loss cruised at any time. Some influences are easily measured and others can only be surmised by general observations.

Modoc National Forest

The timber stand on this area is typically an eastside type, characterized by poor soil and site conditions and poor growth brought about by lack of precipitation. The composition is practically pure ponderosa pine most of which is overmature. Included in the area are sixteen 320-acre sample plots, most of which furnish annual loss records dating back to 1926. The plots are well-scattered and sample all conditions found on the area. They range from site II to site IV, the greater majority averaging site III.

The curves shown in Fig. 1 represent the average percent of total seasonal loss for all plots over a period of years extending from 1926. The plotting of preliminary curves for each plot brought out a definite division into two groups, the average curve for each group being shown by curves "A" and "B". The cause of this cannot be attributed to any one of several factors at this time.

The curves for the Modoc, and similar curves for the other areas studied, show a "flattening" at either end as against the straight line used by Keen. This feature alone would cause considerable error in estimating total seasonal losses from mid-season surveys, and the failure of the straight-line curve in estimation may be attributed in part, at least, to this. The flattening of the curves as described corresponds to the development of the insect broods throughout the season. In the spring, attacks are governed by the emergence of the winter brood and also by weather conditions prior to and during emergence. The rate of appearance of the new attacks is slow at first, increasing with the advent of warm weather, and gradually subsiding as cold weather approaches in the fall.

The differences occurring each year in the average curve shown in Fig. 1, due to a combination of several variable factors, have been plotted as shown in Fig. 3. These differences, or annual variations from the average, are significant in that they vary as much as 45 percent near the end of September when the majority of surveys are made. The annual variation in the percentage of total infestation at the time of the survey apparently varies indirectly as the rate of increase or decrease in the infestation. Theoretically, the percentage of current losses cruised is low during an increasing infestation, other factors remaining constant, and high during a decreasing one. This is illustrated by the table below, based upon infestation conditions in the Modoc National Forest.

Year	Infestation	Estimate
1926	increasing	low
1927	peak-decreasing	high
1928	decreasing	high
1929	decreasing	high
1930	decreasing	high
1931	increasing	average
1932	increasing	low
1933	increasing	low

Some variation in the average curves (Fig.1) appears to exist, depending upon the proportion of primary insects making up the infestation. The majority of attacks of flathead beetles are limited to that period extending from about the first of June to the middle of July. The spotters should be able to cruise nearly 100 percent of the current number of flathead-killed trees by mid-summer, if fading proceeded as in D. brevicomis trees. Cruising experience shows that this is not only impossible at this time, but practically impossible even in late fall. It is generally known that flathead trees are slow in fading, due probably to a combination of weak attacks and the slowing up of the physiological functions of the trees in the fall. There is every reason to believe that this is one of the chief reasons why spotters are able to secure only partial seasonal losses of flathead trees even in late fall cruises.

The curves in Fig. 2 show that on plots in which flatheads are more important as a cause of loss, a smaller percentage of total seasonal loss is cruised on a given date than when pure western pine beetle infestations exist. In practice, this means that on August 1st, a spotter might cruise approximately 30 percent of the total seasonal loss in a western pine beetle infestation, and only about 18 percent if the infestation were primarily a flathead type. Those plots having a mixture of the two should show a cruised loss somewhere between these two figures depending upon the proportion of each species.

Variation due to composition of the stand is insignificant on the Modoc, since the stand is composed entirely of ponderosa pine types.

Lassen National Forest

The area included in the annual forest insect surveys comprises the Eastern Lassen working circle of the Lassen national forest. It is approximately sixty miles south of the area studied on the Modoc, but averages 1000 to 1500 feet higher in elevation than the latter. The composition of the stand varies from pure ponderosa pine to a mixture of ponderosa and Jeffrey pines. Like the Modoc, it is essentially an eastside type and is accompanied by all the adverse growing conditions common to such areas.

Systematic insect surveys have been in progress since 1930 on eight permanent plots of 320 acres each. Though less extensive than the Modoc, the loss records are sufficient to show several pronounced differences regarding the use of correction factors for estimating total seasonal losses.

The method used in plotting the two curves shown in Fig. 4 was somewhat different than that used for corresponding curves on the Modoc due to limited survey records. Instead of plotting preliminary curves for each plot, the percentage of total seasonal loss cruised each year for all plots was plotted to form the basis of each of the curves shown.

The higher elevation of the Lassen area is reflected in the percentage of seasonal loss cruised on certain dates as compared to that cruised on the Modoc on similar dates. In the former, for instance, 10 percent of the total seasonal western pine beetle loss is usually obtained from cruises about August 10th, whereas the same percentage on the Modoc is usually picked up from June 10th to July 10th. This is in line with Hopkin's Bioclimatic Law. The rate of increase in seasonal losses is much more rapid but of shorter duration due, apparently, to the shorter season in which brood development occurs.

The record of annual losses on the Lassen is too limited to determine the annual variation in the correction factor under changing conditions. It is believed, however, that the increase or decrease in the infestation for any one year will have the same effect upon estimations of seasonal losses as was shown to exist in the Modoc area.

The composition of the infestation in ponderosa pine is predominately D. brevicomis. Species of Melanophila are in the minority and are not considered, up to the present time at least, as one of the primary insects on the area.

Jeffrey pine occurs in mixture with ponderosa pine over much of the area and in some localities approaches dominance. The loss percentage curves shown in Figure 4 for the two species are similar enough throughout the average season to disregard the differences due to host. This simplifies the estimation of seasonal losses and is an advantage because of the fact that Jeffrey pine is included in Forest Service timber sales as ponderosa, or yellow, pine.

Plumas National Forest

Annual surveys have been in progress on the Eastern Plumas working circle only since 1933. This fact limits a detailed study of correction factors on this area. The close proximity of this area to the eastern Lassen National Forest and the similarity of conditions on the two leads to the belief that the correction factors used on the Lassen may also be effective on the eastern Plumas. Provisions must be made, however, for local variable conditions.

Westside Sierra Region

The commercial pine forests of California are divided into east and westside types depending upon their location with reference to the Sierra Nevada mountain range. The former type includes such stands as are encountered on the Modoc, eastern Lassen, and eastern Plumas National Forests. The westside pine stands include those extending along the west side of the Sierras from Mt. Lassen on the north to the Tehachapis on the south. They range from pure ponderosa pine at lower elevations above the foothills to a mixture of ponderosa and sugar pine at higher elevations.

Climatic conditions on the westside are much more favorable to tree growth. Precipitation is several times as great which, combined with a longer growing season, milder winters, and better site and soil conditions, produces timber with a faster growth rate, of better quality, and a larger volume per acre.

Systematic loss records have been limited to the Sierra National forest and to a lesser degree to the Stanislaus National Forest and Yosemite National Park. Such records do not, with few exceptions, occur earlier than 1931. Because of this, the curves shown in Fig. 5 were plotted by the same method as described for the Lassen area, except that three divisions of the field records were made; namely, ponderosa pine losses at low elevations, ponderosa pine losses at high elevations, and sugar pine losses.

Such factors as annual variations in the curves influenced by a combination of other factors, change in the infestation trend, and in the composition of the infestation cannot be accurately determined from the short period of annual survey records. Their effect upon the proper estimation of seasonal losses based upon cruised losses is probably the same as was found in the northern forests. The use of these allowances and correction curves for several seasons will prove or discredit this theory.

Slight differences occurred in the percent of seasonal losses cruised in ponderosa pine stands in low and high elevations on the same dates, as shown in Fig. 5. Losses at the higher elevations appear later in the spring and reach the seasonal total earlier in the fall than those at lower elevationss Allowances in the use of the proper correction factor should be made on those areas where differences in elevations are great.

The estimation of seasonal losses in sugar pine from cruised losses has been a source of considerable error. The curve for sugar pine in Fig. 5 shows a total of 72 percent of the seasonal loss cruised the middle of October in comparison to 92 percent for ponderosa pine at the same elevation. It is evident that 100 percent of the sugar pine loss is not in evidence until midwinter or early the following spring. This is further substantiated by general observations and by brood studies carried on by Struble for sugar pine in the Sierra National Forest. As a possible explanation of this, evidence has shown that many late fall attacks of sugar pine by Dendroctonus monticolae Hopk. are not noticeable to spotters until the following spring, due to the delayed fading of the trees. For instance, while 100 percent of the number of infested trees for any one year may actually be present late in the fall, the spotters on the same date might actually record only about 80 or 85 percent.

Discussion

The use of the accompanying curves for accurate determination of the percentage of the total losses found in the survey depend upon the proper allowance of one or several of the following variables that have been found to be effective in the areas under study:

1. Trend of infestation.
2. Composition of infestation
3. Composition of stand.
4. Climatic influences
5. Elevation.
6. Variation in spotting.

Trend of Infestation:

Sudden increase or decrease in an infestation apparently has an appreciable effect upon the use of a proper correction factor to be applied to the survey data. A sudden increase during or following the survey will normally result in estimating the total seasonal losses too low. To offset this, the percent figure read from the curve for the date of the survey must be decreased according to the judgment of the estimator. Changes in the trend of infestations may be due to natural causes or to control operations, fires, blowdowns, etc.

Composition of Infestation:

The effect of more than one primary insect composing the infestation in one host species may be felt if the normal development of the several insect species is not coincident. This applies particularly to the Modoc area at present where Melanophila beetles are becoming quite important as primary insects. It has been shown in Fig. 2 that an increase in the proportion of flathead beetles would lower the percentage of total seasonal loss secured at the time of the survey.

Composition of Stand:

The mixture of species making up the pine stand in any area may modify the seasonal loss estimates. The time and rate of development of the losses throughout any one season may vary according to the pine species present, their proportion in the stand, and the primary insects attacking them. As was previously mentioned, Jeffrey pine losses on the Lassen developed throughout the average season at practically the same rate as those in ponderosa pine. This was presumed to be the case also in the eastern Plumas ponderosa-Jeffrey pine stands.

On the other hand, sugar and ponderosa pine losses on the west side of the Sierras presented different rates of development of seasonal losses. Any estimations made of the total seasonal loss based upon cruised losses would, therefore, be the result of two separate estimations; one each for sugar and ponderosa pine.

Areas which contain pure stands of only one pine species, such as the Modoc and portions of the Lassen, Plumas and westside Sierra region, are usually the simplest to estimate.

Climatic Conditions:

The correlation of the number of clear days or mean monthly temperatures to the rate of occurrence of insect losses cannot be measured directly

with existing data. General observations of weather conditions affecting brood development is apparently one of the best criterions for measuring the climatic influences. Thus an early and continued warm spring results in earlier insect development. The losses appear earlier, and, other things being equal, the percentage of total losses cruised in early summer are usually higher. Climatic conditions in the fall effect the estimations in much the same manner.

Elevation:

The effect of elevation in estimating seasonal losses is best seen by comparing the curves for D. brevicomis in the Modoc with that in the Lassen (Fig. 1 and 4), and also the two curves for ponderosa pine at different elevations in the westside Sierra type (Fig. 5). In general, losses occurring at high elevations appear later in the season and terminate earlier than at lower elevations. The northern forests are fairly uniform in topography and elevation and no correction for this factor is necessary. It becomes important, however, in the westside region due to ruggedness of the country and rapid changes in elevation.

Variation in Spotting:

Keen has shown that the efficiency of individual spotters may prove to be quire a factor in estimating. He points out, "In general, it may be said that the spotter getting the most trees (using two spotters per crew) will come the nearest to the actual number on his half of the section, so that if one man is consistently running low, it is probable that he is missing trees. This is not always the case, however, as the other spotter may be covering too large a strip or may be marking trees which should properly be excluded from the count."

Experience has shown that the efficiency of the average spotter varies with such conditions as shown below:

1. Training and experience.
2. Time of year.
3. Speed with which work is pushed.
4. Topography and type of infestation.
5. Weather conditions.
6. General morale of the man due to living conditions personality, and willingness to cooperate.

Personal errors in spotting will probably always occur but should be kept to a minimum by the use of experienced men, careful selection and training of new men, and proper supervision of the work.

Conclusion

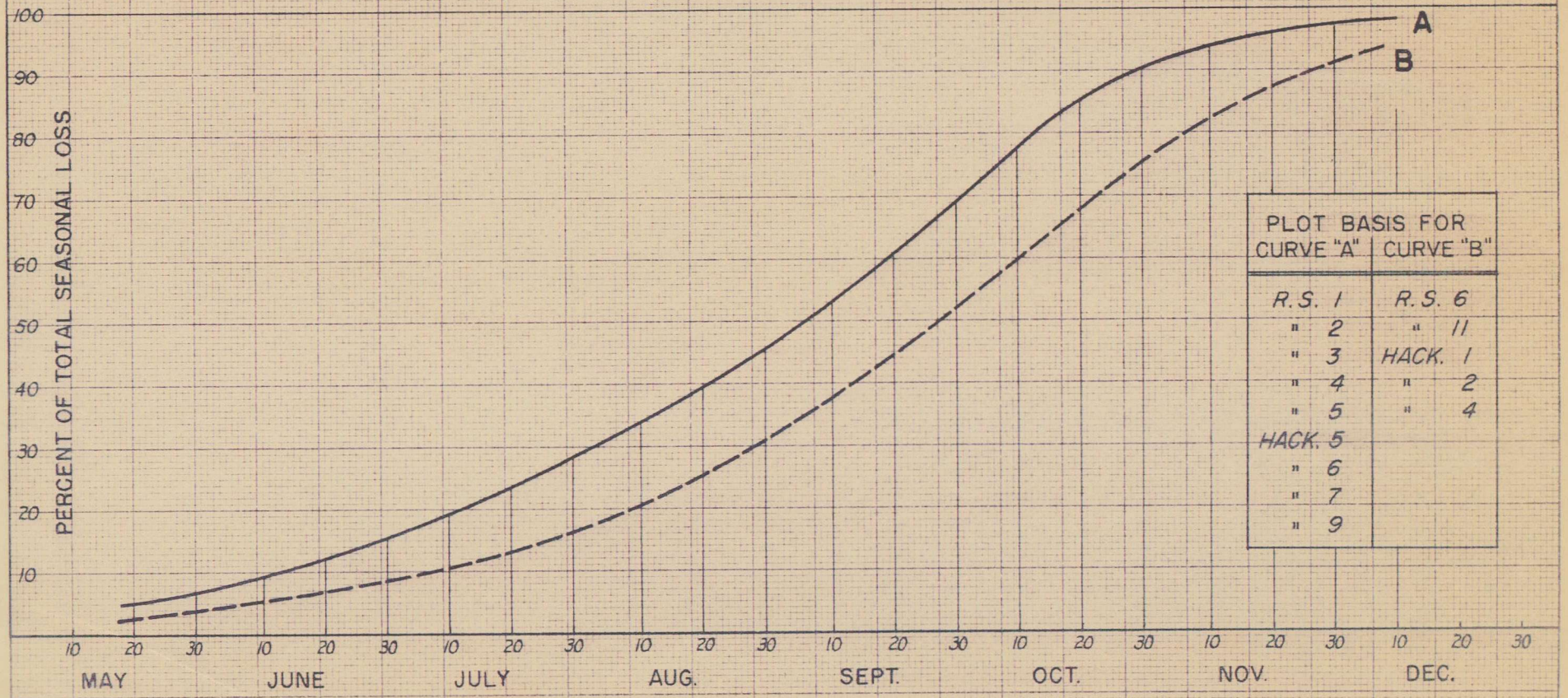
The curves presented as a basis for proper correction factors for use in estimating are supported by limited data and are, therefore, subject to revision through use. The value of a systematic survey carried out each year has been of great value in a study of this nature and the continuing of such surveys on an annual basis will improve the accuracy of studies based upon infestation records over long periods.

FIG. 1

PERCENT OF TOTAL SEASONAL LOSS CRUISED ON ANY DATE

PONDEROSA PINE — ALL PRIMARY INSECTS

MODOC NATIONAL FOREST, CALIFORNIA



PLOT BASIS FOR CURVE "A"	CURVE "B"
R.S. 1	R.S. 6
" 2	" 11
" 3	HACK. 1
" 4	" 2
" 5	" 4
HACK. 5	
" 6	
" 7	
" 9	

FIG. 2

PERCENT OF TOTAL SEASONAL LOSS CRUISED ON ANY DATE

DENDROCTONUS BREVICOMIS LEC. AND *MELANOPHILA* SPP. IN PONDEROSA PINE

MODOC NATIONAL FOREST, CALIFORNIA

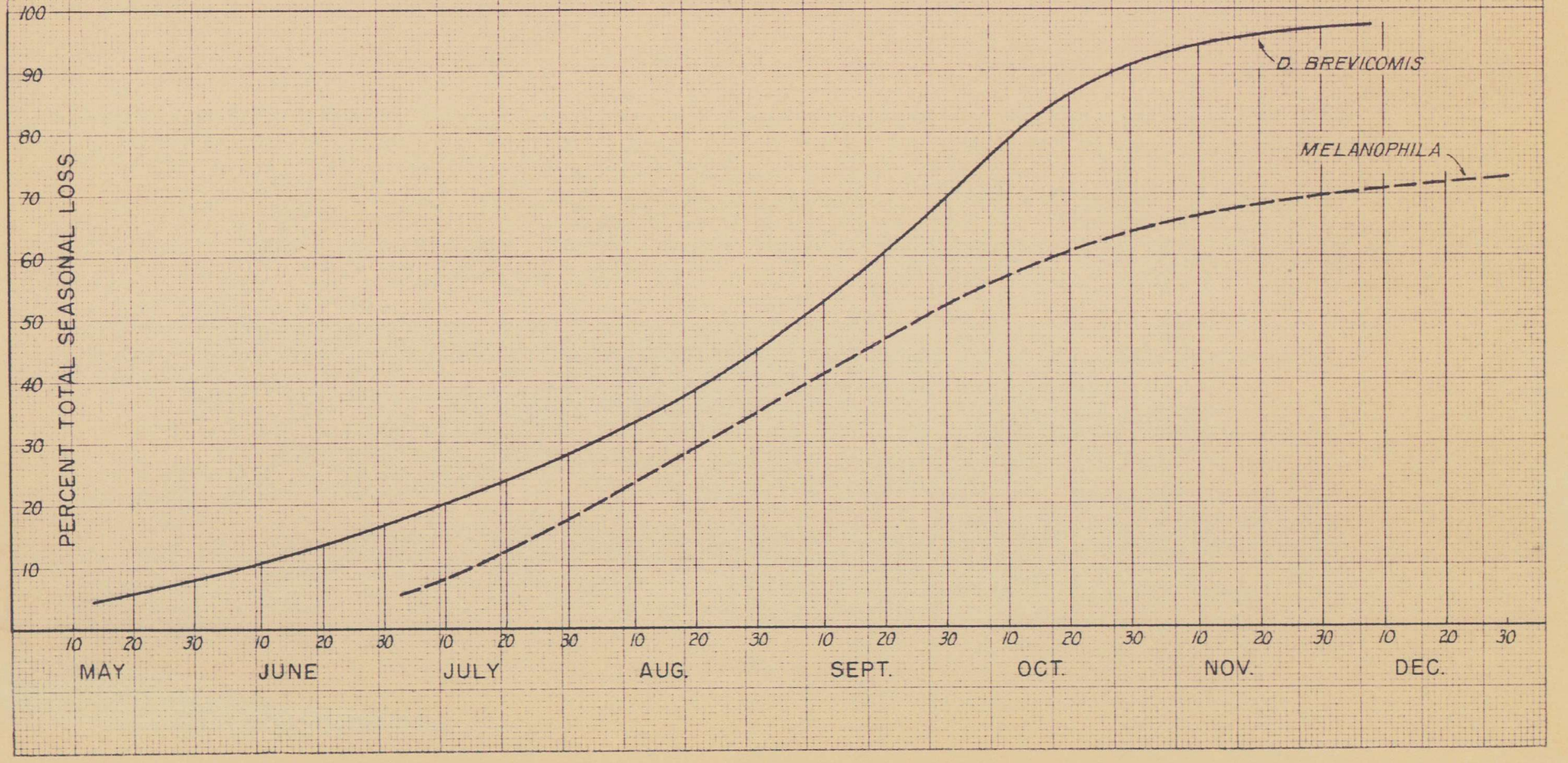


FIG. 3

ANNUAL VARIATION
IN
PERCENT OF TOTAL SEASONAL LOSS CRUISED ON ANY DATE

PONDEROSA PINE — ALL PRIMARY INSECTS

MODOC NATIONAL FOREST, CALIFORNIA

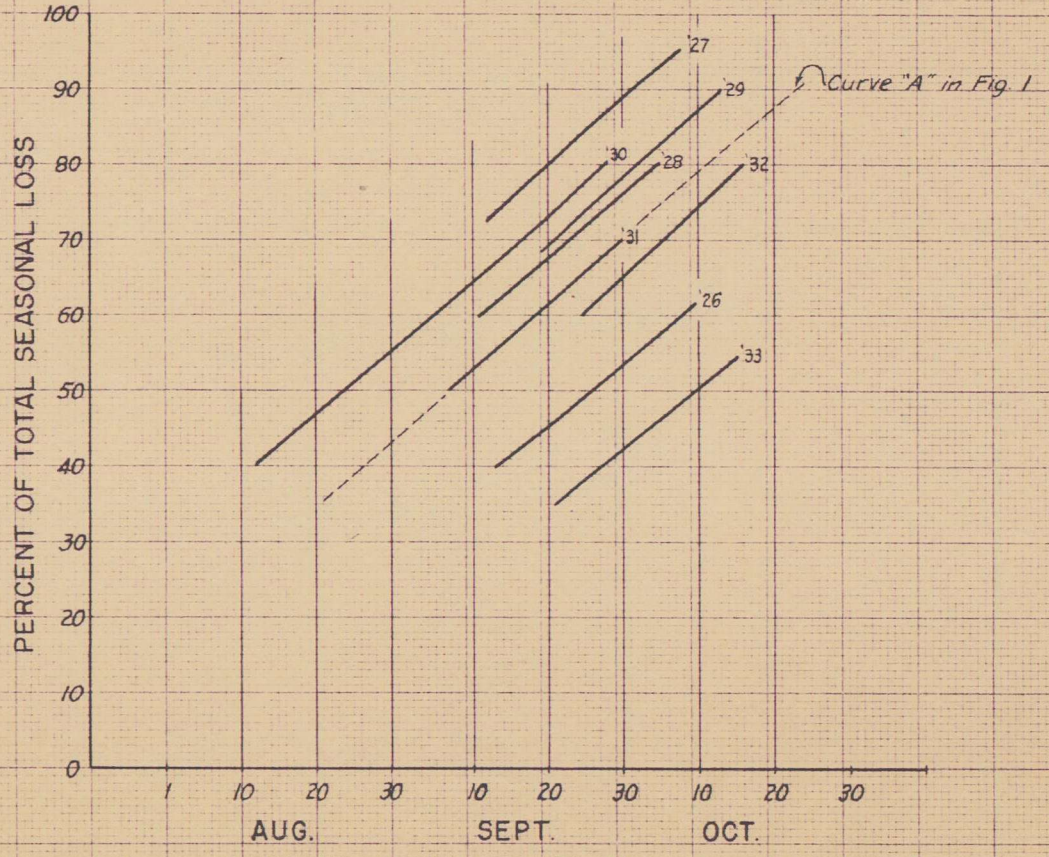


FIG. 4

PERCENT OF TOTAL SEASONAL LOSS CRUISED ON ANY DATE

PONDEROSA AND JEFFREY PINE ALL PRIMARY INSECTS

LASSEN NATIONAL FOREST, CALIFORNIA

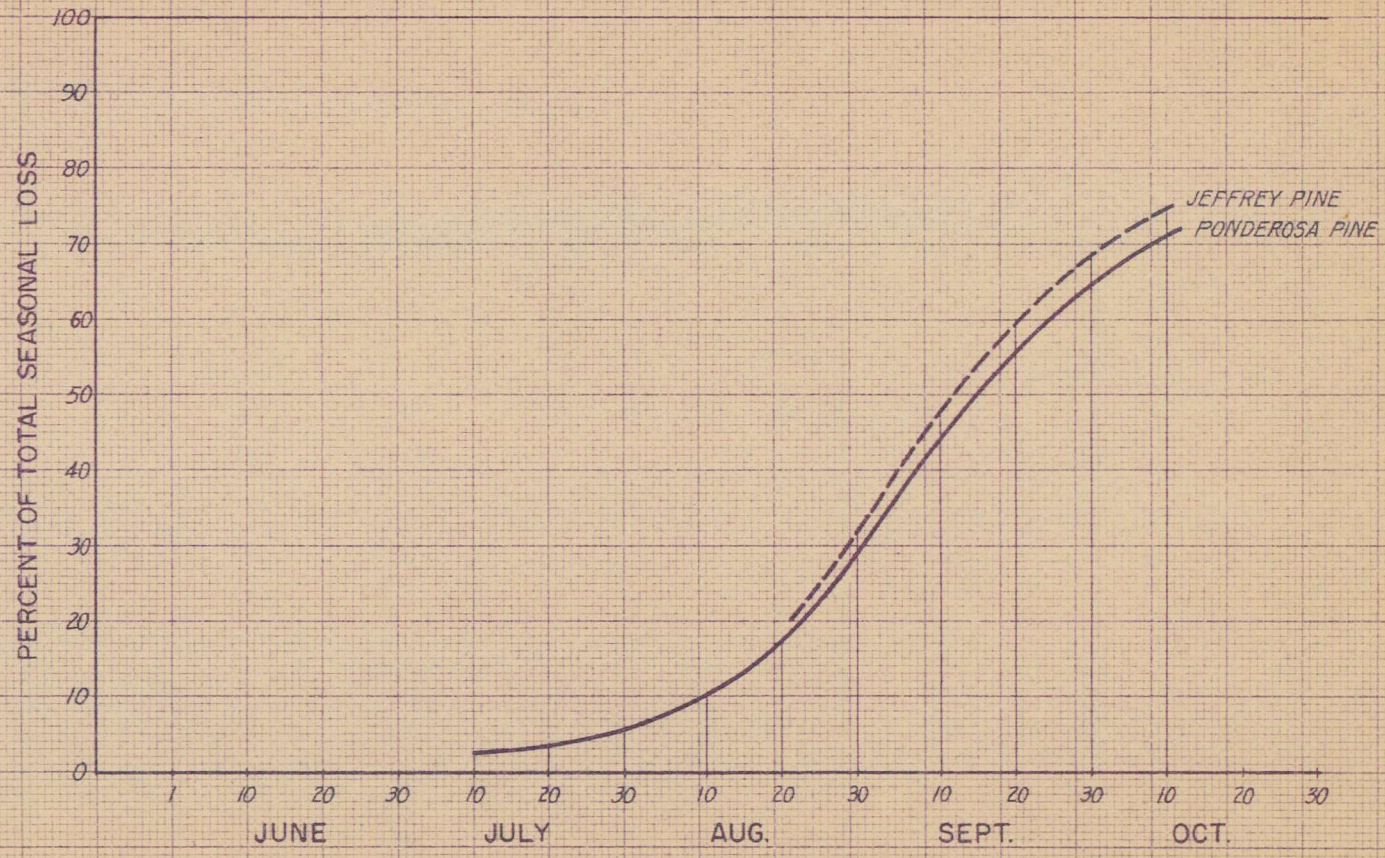


FIG. 5

PERCENT OF TOTAL SEASONAL LOSS CRUISED ON ANY DATE

PONDEROSA AND SUGAR PINE — ALL PRIMARY INSECTS

WESTSIDE SIERRA REGION, CALIFORNIA